Original scientific paper

UDC: 159.953.2:159.942

Received: April 05, 2025.
Revised: July 28, 2025.
Accepted: August 02, 2025.

10.23947/2334-8496-2025-13-2-311-322

The Effect of Emotional Charge of Visual Stimuli on Memorization and False Recognition

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Abstract: Various sensory stimuli, including visual ones, carry certain emotional characteristics. Given that the brain continuously processes a vast number of sensory inputs, inevitably, memory and emotions are intrinsically linked. This study aims to explore the connection between experience and cognitive performance. Through a quantitative experimental design, it has been demonstrated that individuals are more likely to remember emotionally charged visual stimuli compared to neutral visual stimuli. Additionally, a significant effect of emotional charge on memory recall was identified, with a positively charged stimuli being remembered more effectively than neutral ones. From the perspective of specific emotional charge, a preference for greater enjoyment of positively charged emotional stimuli over negatively charged ones was also observed. However, the effect of emotional charge on the occurrence of false associations was not confirmed, as no differences in false associations were found between emotionally charged and neutral visual stimuli. This knowledge can enhance our understanding of cognitive processes within the Slovak population and may serve as a foundation for future research in the field of cognitive sciences.

Keywords: *emotional charge, false recognition, memory, remembering, visual stimulus.*

Introduction

Emotions are present in nearly every moment of people's daily lives, adding depth to their experiences with the world. The objects individuals encounter serve as carriers of specific emotional characteristics that can evoke a range of emotions, depending on the individual's personal experiences and psychological state. Emotions are influenced by a network of interconnected structures in the brain known as the limbic system (Rajmohan and Mohandas, 2007). These structures are intrinsically linked to cognitive abilities and influence cognitive processes such as attention, memory, and executive functions. Memory and emotions are fundamentally linked, as both involve brain activity (Phan et al., 2002). Pilarczyk and Kuniecki (2014) indicate that emotionally charged stimuli are prioritized during processing, and memory retention is enhanced for such stimuli (Harris and Pashler, 2005). However, this study focuses only on events and words with an emotional charge. Furthermore, it has confirmed that memory for emotionally charged words, particularly negative ones, is superior to that for neutral words (Harris and Pashler, 2005). Other studies suggest that adults tend to prefer and remember positive stimuli more than negative stimuli, as they are generally more recognizable, as the left hemisphere is particularly involved in processing positive emotional stimuli during memory tasks (Balcony and Ferrari, 2012; Madan, Scott and Kensinger, 2019). Conversely, some studies (Harris and Pashler, 2005; Quevedo et al., 2003) suggest that emotionally charged stimuli may lead to reduced memory retention rather than enhancement. Quevedo et al. (2003) demonstrated that the positive effects of emotions on memory become evident only after extended retention intervals, with no significant differences observed during shorter intervals.

Research indicates that emotional stimuli tend to evoke more false memories than neutral stimuli, and individuals are more likely to falsely remember negative stimuli than positive or neutral ones (Dehon et al., 2010). The state in which a non-presented object elicits an illusory sense of recollection is referred

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to as phantom memory or false memory (Gong et al., 2016). The prefrontal cortex plays a significant role in this process, as it is partially responsible for encoding, searching, and evaluating memories (Johnson, 2001). Zheng et al. (2019) found that false recognition memory shows a preference for positive over negative emotional stimuli, indicating that false recognition is more likely to occur with positive emotional stimuli. Another study revealed that the false recall effect occurs even more frequently for negatively valenced stimuli than for those with positive valence (Dehon et al., 2010). One of the most common explanations is that the influence of affective charge causes a narrowing of attention, leading to selective memory and memory illusions, as individuals tend to better memorize the central details during negative arousal but have poorer encoding of peripheral information, which creates a foundation for memory distortions (Kensinger, 2009).

The study by Carstensen et al. (2003) suggests that age significantly affects the processing of visual stimuli in the adult population (Isaacowitz et al., 2006), referencing the theory of socioemotional selectivity. This theory posits that age serves as a predispositional factor in a motivational shift toward emotional goals. However, most studies examining the impact of emotional visual stimuli on memory have mostly focused on either childhood or the period of middle to late adulthood; consequently, there is a notable lack of research investigating the effects of emotional static visual stimuli in young to middle adulthood. Overall, the findings regarding emotional stimuli and their effect on memory are contradictory. Additionally, there is insufficient evidence related to the recall of emotionally charged or neutral stimuli in the Slovak population, as well as a lack of studies focused on the false recognition of visual stimuli potentially influenced by Slovak culture.

In this study, we examine stimuli that require temporary storage but have already undergone the storage process. This suggests that these stimuli have entered long-term memory through memorization. Empirical evidence indicates that emotions can enhance long-term memory; however, they can also have a detrimental effect by reducing the quantity of remembered information or by distorting, leading to false recognition (Zheng et al., 2019). The ambiguous effects of emotional stimuli can be further investigated by presenting the stimuli and recording their re-recognition.

Objectives of the study

The relationship between emotional visual stimuli and their impact on memory retention and false recognitions is quite complex, and the findings show inconsistency. Therefore, several research goals were established to enhance the understanding of experience and cognitive performance:

- Identify the effect of the emotional charge of visual stimuli on memory retention.
- Verify the differences in memorization between emotionally charged visual stimuli and neutral visual stimuli.
- Identify the differences in the number of false associations when recognizing emotionally charged and neutral visual stimuli.

Based on the previous research findings and current research objectives, the following hypotheses were formulated:

1. We assume that individuals will remember emotionally charged visual stimuli more effectively compared to neutral visual stimuli.
2. We assume that individuals remember positive emotional stimuli more effectively than negative emotional stimuli.
3. We assume that when re-recognizing emotionally charged visual stimuli, there will be more false associations than when visual stimuli are neutral.
4. We assume that with positive emotional stimuli, there are more false associations than with negative emotional stimuli.

Materials and Methods

Research sample

The research sample consisted of 38 participants. The sample size was selected to align with the sample sizes of similar studies (e.g., Quevedo et al., 2003; Gong et al., 2016; Maksimainen et al., 2018). A non-random method was selected, and individual participation was voluntary. All participants were psy-

chology students from a university in Slovakia. In terms of gender differences, there was a notable predominance of females in the study (n = 30) over males (n = 8). The mean age of the total sample was 26.16 years (SD = 7.32). The mean age for males was 30.38 years (SD = 9.58), while the mean age of females was significantly lower at 25.03 years (SD = 6.33). The youngest participant in the study was 21 years old for both genders, and the oldest participant was 48 years old among females and 46 years old among males.

Procedure

A within-subject design was implemented, and each participant was exposed to all three levels of the independent variable – positive, negative and neutral emotional stimuli. The dependent variable in this study was memorization. This study consisted of three parts: presentation, memory, and verification. The emotional stimuli were subsequently categorized into photographs with a positive emotional valence and those with a negative emotional valence. Ultimately, emotional valence encompassed three different levels (neutral, positive, and negative). The stimuli were selected from the GAPED database, an internationally recognized database (Dan-Glauser and Scherer, 2011) that has been demonstrated to be a reliable database with proven validation of affective stimuli (Balsamo et al., 2020). The use of photographs from the GAPED database was contingent upon guidelines permitting users to utilize the database for research purposes, allowing researchers to share (copy, transfer) and remix (adapt) the source materials (Dan-Glauser and Scherer, 2011). Photographs were selected for each category primarily based on their determined valence, which is a fundamental factor in the experimental stimuli. The key stimuli comprised 15 photographs. In the presentation phase, visual stimuli of negative valence included images A024, A039, A059, Sn022, and Sp036 from the GAPED database (Dan-Glauser and Scherer, 2011). The positive stimuli category included photographs P017, P031, P037, P077, P081, and P114, while neutral stimuli were represented by photographs N011, N020, N061, N081, and N089. For photographs with a negative emotional charge, ethical considerations were taken into account, including adherence to valid internal (moral) norms, with an average score of 41.05, and external (legal) norms, with an average score of 50.33. The database is constructed in such a way that positive and negative objects are animate, and neutral objects are mainly inanimate, due to the need for the absence of affective valence. All photographs were uniformly sized at 640x480 pixels. The visual stimuli included in the first part of the study are shown in Figures 1, 2, and 3. Three versions with different arrangements of stimuli were created to demonstrate that the order of the photographs does not influence the participants' ability to recall the stimuli. The visual stimuli (photographs) were presented to participants via Microsoft PowerPoint in full-screen mode on a computer screen. Each slide contained one image, and the slides were automatically advanced at fixed intervals. Participants were seated approximately 60 cm from the display and were instructed to remember the scenes as accurately as possible. Head movements were not restricted. Throughout the experiment, a white fixation point appeared on a grey background in the center of the screen for 2 seconds. The fixation point was placed in the center of the screen, and photographs with varying affective charges were presented in the middle of the screen. Each photograph was displayed for 6 seconds. Following the presentation part, a countdown from 15 to 1 was shown on the monitor screen, after which memory performance was assessed. During the memory part, participants were asked to describe the scenes they had observed in the presentation phase in any order they wished. This memory phase was not time-limited and lasted an average of 13 minutes. The verification and re-recognition phase included a total of 36 visual stimuli arranged in an identical layout, consisting of 12 stimuli for each type of emotional charge. This phase featured 15 stimuli from the presentation phase and 21 new stimuli of similar valence. In the verification phase, participants indicated whether they had seen each photograph during the presentation phase. They were given 7 seconds to respond to each photo. Given that previous research has shown that emotional stimuli tend to elicit more false memories than neutral stimuli and can also impair memory based on their valence (Dehon, Larøi, and Van der Linden, 2010), which is characterized as false recognition (Zheng, et al., 2019). This additional section was considered beneficial for validating false recognition.

Figure 1. Visual stimuli - photographs with a negative emotional charge (Dan-Glauser and Scherer, 2011)

Figure 2. Visual stimuli - photographs with a positive emotional charge (Dan-Glauser and Scherer, 2011)

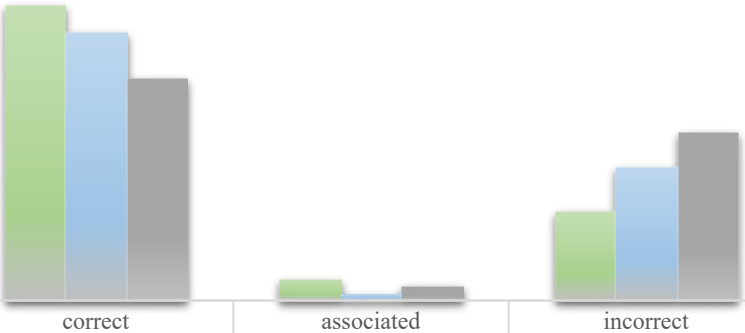
Figure 3. Visual stimuli - photographs with a neutral emotional charge (Dan-Glauser and Scherer, 2011)

In terms of ethical considerations, it was essential to ensure the objectivity and neutrality of the experimenter while safeguarding sensitive data. Participants in the experiment were informed about the purpose of the research, data protection measures and were provided with an informed consent form to sign before the experiment commenced. This form emphasized ethical principles and participants' right to withdraw from the study at any time. Each participant had taken part in the experiment individually but under the supervision of an experimenter, who guided them throughout the experiment. The experiment lasted for approximately 30 minutes. The laboratory experiment was followed by a content analysis of the text. The content analysis included three analytical categories: correct, associated, and incorrect responses. A three-point scoring system (0 - incorrect, 1 - associated, 2 - correct response) was developed to capture scores for remembered stimuli with specific emotional charge, as well as scores for false

associations across the three types of emotional charge. During the verification phase, responses were classified as either correct or incorrect.

Results

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, repeated-measures ANOVA, and paired-samples t-tests were employed to test the stated hypotheses. Effect sizes were reported using partial eta squared (η^2) for ANOVA and Cohen's d for t-tests, following conventional interpretation thresholds. The use of established analytical procedures and statistical software contributes to the methodological transparency and reproducibility of the study (Field, 2013). In terms of describing the different categories of emotional charge *(hereafter referred to as "ECH"),* the category of photos with a positive ECH was the most frequently recalled, yielding a total number of 138 correct responses. This was followed by the category with a negative ECH, with 125 correct responses. The least accurately remembered were the neutral photographs, with only 104 correct responses. The mentioned scores can be seen in Graph 1. Between the positive and negative visual stimuli, there was a difference of 13 correct responses, favoring the positive ones. The greatest number of incorrect responses was recorded in the neutral ECH category.



	correct	associated	incorrect
positive	138	10	42
negative	125	3	62
neutral	104	7	79

Graph 1. Correctness of answers for three types of emotional charge

To evaluate the assumption of normality, visual inspection through Q-Q plots and histograms was conducted. Given the sample size (N = 38), visual methods were considered more reliable than numerical tests (Field, 2013). The visual inspection did not indicate substantial departures from normality. Therefore, the use of parametric tests (ANOVA and paired-samples t-tests) was deemed appropriate.

To test the first hypothesis, which assumed that emotionally charged visual stimuli would be remembered more effectively than neutral stimuli, a repeated-measures ANOVA was conducted to examine the effect of stimulus valence (positive, negative, neutral, and emotional overall) on the accuracy of participants' responses. The assumption of sphericity was violated, as indicated by Mauchly's test, W = .000, χ^2 (5) = 10.149, p = .006; thus, the Greenhouse–Geisser correction was applied. The analysis revealed a statistically significant main effect of valence, F (1.61, 59.41) = 8.37, p = .001, partial η^2 = .184, indicating that the type of stimulus significantly influenced memory performance.

To further examine the nature of this effect, polynomial contrasts were conducted (see Table 1). A significant linear trend was observed, F (1, 37) = 14.31, p = .001, partial η^2 = .279, suggesting a consistent difference in memory performance across stimulus types. Additionally, a significant quadratic trend was found with the same F-value and effect size, indicating non-linear variation. The cubic trend approached significance, F (1, 37) = 3.75, p = .060, partial η^2 = .092.

Table 1. *Results of Polynomial Contrasts for the Effect of Valence (Repeated Measures ANOVA)*

Contrast Type	SS	df	MS	F	p	Partial η²
Linear	2.158	1	2.158	14.313	.001	.279
Quadratic	10.791	1	10.791	14.313	.001	.279
Cubic	4.200	1	4.200	3.751	.060	.092

Note: SS = Type III Sum of Squares, MS = Mean Square, η² = Eta squared

Descriptive statistics showed that participants achieved the highest average score in the category of positive stimuli (M = 3.63, SD = 1.03), followed by emotionally charged stimuli (M = 3.46, SD = 0.90), negative stimuli (M = 3.29, SD = 1.01), and neutral stimuli (M = 2.74, SD = 1.03). These results support the hypothesis that emotionally charged visual stimuli are better remembered than neutral ones.

The difference in the scores of correct answers between emotionally charged and neutral stimuli was statistically significant ($p < 0.05$). The mean score of differences for the various types of emotional charge was 0.724 (SD = 1.441), as can be seen in Table 2. These results support the hypothesis that emotionally charged visual stimuli are remembered more effectively by individuals than neutral visual stimuli. An effect size of 0.745 was observed between neutral and emotional visual stimuli, which, according to Cohen's criteria, can be classified as a medium effect size of emotional charge on recall (Sullivan and Feinn, 2012). Degrees of freedom (df) in this analysis were 37. The "df" is indicated in the table next to the value of the t-test (t) in parentheses.

Table 2. *The result of the paired t-test - hypothesis no. 1 - the average differences in the score of correct responses*

		M	SD	t (37)	p	Cohen's *d*
Pair 1	Positive emotional charge Neutral emotional charge	0.895	1.521	3.627	0.001	0.865
Pair 2	Negative emotional charge Neutral emotional charge	0.553	1.519	2.242	0.031	0.538
Pair 3	Emotional charge Neutral emotional charge	0.724	1.441	3.095	0.004	0.745

In Hypothesis 2, we assumed that individuals will remember positive emotional stimuli more effectively than those of negative emotional stimuli. The differences in mean score for different types of emotional charge is statistically significant ($p < 0.05$), with a mean difference of 0.342 (SD = 0.966).

The results of the t-test (as shown in Table 3) support the hypothesis that individuals remember positive emotional stimuli more effectively than negative emotional stimuli. The effect of emotional charge on remembering has a value of Cohen's $d = 0.334$, indicating a small effect size.

Table 3. *The result of the paired t-test - hypothesis no. 2 – the average differences in the score of correct responses*

		M	SD	t (37)	p	Cohen's *d*
Pair 1	Positive emotional charge Negative emotional charge	0.342	0.966	2.182	0.036	0.334

In Hypothesis 3, we assumed that when re-recognizing emotionally charged visual stimuli, there would be more false associations than when visual stimuli are neutral. Descriptive statistics in identifying the difference in memorization and false recognition revealed a total of 55 false associations, accounting for 4.02% of all responses.

To complement the t-test analyses, a repeated-measures ANOVA was conducted to examine whether the number of false associations differed significantly depending on the emotional valence of the stimuli (neutral, positive, and negative). Mauchly's test indicated a violation of the assumption of sphericity, $\chi^2 (2) = 10.553$, $p = .005$. Therefore, the Greenhouse–Geisser correction was applied. The analysis did not reveal a statistically significant main effect of valence, $F (1.60, 59.41) = 0.519$, $p = .557$, partial $\eta^2 = .014$, suggesting that the emotional charge of stimuli did not significantly affect the frequency of false associations.

Polynomial contrasts further confirmed the absence of significant trends: the linear trend was non-significant, $F (1, 37) = 1.207$, $p = .279$, $\eta^2 = .032$, as was the quadratic trend, $F (1, 37) = 0.107$, $p = .745$, $\eta^2 =$

.003 (see Table 4).

Table 4. *Results of repeated-measures ANOVA - hypothesis no. 3 – false associations by emotional valence*

Effect	df (GG)	F	p	Partial η²
Valence (Greenhouse-Geisser)	1.60, 59.41	0.519	.557	.014
Linear Contrast	1, 37	1.207	.279	.032
Quadratic Contrast	1, 37	0.107	.745	.003

Descriptive statistics showed that the mean number of false associations was lowest for neutral stimuli (M = 0.42, SD = 0.64), slightly higher for positive stimuli (M = 0.45, SD = 1.08), and highest for negative stimuli (M = 0.58, SD = 0.72). Pairwise comparisons between the types of stimuli showed no significant differences (all p > .05), consistent with the t-test findings.

To further explore potential pairwise differences in false associations, we conducted series of paired t-tests was also conducted to analyze three stimulus pairings based on the research hypothesis. The results presented in Table 5 did not reveal statistically significant differences (all p > .05) in false associations between neutral visual stimuli and either positively or negatively charged stimuli, nor between neutral and overall, emotionally charged stimuli.

Table 5. *The result of the paired t-test - hypothesis no. 3 – score of false associations*

		M	SD	t (37)	p	Cohen's *d*
Pair 1	Positive emotional charge Neutral emotional charge	0.026	0.885	0.183	0.856	1.034
Pair 2	Negative emotional charge Neutral emotional charge	0.158	0.886	1.098	0.279	0.234
Pair 3	Emotional charge Neutral emotional charge	0.092	0.624	0.909	0.369	0.141

These results do not support Hypothesis 3, which predicted that emotionally charged visual stimuli would elicit a greater number of false associations than neutral stimuli. Both the ANOVA and paired-samples t-tests consistently indicated no statistically significant differences in the number of false associations across stimulus valence conditions.

In Hypothesis 4, we assumed that there would be more false associations with positive stimuli than with negative emotional stimuli. In the analysis of spurious associations between different ECH types, the mean difference is -0.132 (SD = 1.26). The paired-samples t-test revealed no statistically significant difference between positive and negative emotional stimuli in the number of false associations, t(37) = -0.646, p = .522, Cohen's d = 0.141 (see Table 6).

Table 6. *The result of the paired t-test - hypothesis no. 4 – score of false associations*

		M	SD	t (37)	p	Cohen's *d*
Pair 1	Positive emotional charge Negative emotional charge	-0.132	1.256	-0.646	0.522	0.141

These results do not support the assumption that there will be more false associations with positively charged emotional stimuli than with negatively charged emotional stimuli.

Discussions

The study examined the effect of the emotional charge of visual stimuli on memory retention and the occurrence of false associations during re-recognition. In the first hypothesis, we assumed that individuals will remember emotionally charged visual stimuli more effectively than neutral visual stimuli. The findings showed that individuals were able to remember more emotional stimuli than neutral ones, which is consistent with previous research (Humphreys et al., 2010; Pilarczyk and Kuniecki, 2014). From a cognitive psychology perspective, enhanced recall can be attributed to the inherent salience of affective stimuli, which capture more attention than neutral stimuli. Consequently, individuals tend to allocate greater attention during the encoding process when focusing on emotional items (Talmi et al., 2008).

Furthermore, the social context may also be a contributing factor in shaping past emotional experiences, leading individuals to exhibit a stronger inclination towards emotional stimuli (Maksimainen et al., 2018). However, it is important to note that the perception and processing of emotional information are also shaped by cultural background. Cross-cultural studies have shown that attentional patterns, emotional salience, and even neural processing differ across cultures. For example, individuals from Western, individualist cultures tend to focus more on personal emotional experiences and discrete emotional expressions, whereas individuals from East Asia are more likely to consider social context and may regulate or suppress emotional responses accordingly (Matsumoto et al., 2008).

Finally, the neuropsychological basis for improved memory of emotional stimuli lies in brain function. Emotions trigger high-frequency brain waves in the amygdala, a key brain structure responsible for heightened activation of cognitive functions (Kensinger, 2009). When an individual perceives an emotional component, the amygdala is activated, resulting in the production of adrenaline, which in turn stimulates the hippocampus, enhancing the encoding of emotional memories (Tambini et al., 2016). During emotionally charged events, the brain releases neurotransmitters such as adrenaline and cortisol, which facilitate encoding and recall. In simple terms, people are drawn to the emotional intensity and vividness that emotions evoke, leading them to remember emotional stimuli more effectively than neutral stimuli. Ultimately, the effect of emotional intensity on memory retention is due to a complex interplay among neurochemical, cognitive, social, and neural factors.

In the second hypothesis, we assumed that individuals would remember positive emotional stimuli more effectively than negative emotional stimuli, which was confirmed by our results and individuals remembered positive emotional stimuli more effectively than negative emotional stimuli. Our findings demonstrated that they are in line with previous research, which has confirmed that positive emotional content creates stronger memory traces, leading to higher memorability (Bessette-Symons, 2017; Zheng et al., 2019). Positive emotional stimuli tend to remain in the memory longer and are recalled more frequently than negative emotional stimuli. This phenomenon may be attributed to the brain's response to positive emotional stimuli, which triggers the amygdala to release hormones such as dopamine and serotonin. These neurotransmitters enhance the individual's ability to remember the stimulus more vividly (Kelly, 2017). One possible explanation for why individuals exhibit better memory for positively charged stimuli is an intrinsic desire to maintain a positive outlook on life, as well as an effort to forget the unpleasant experiences. Additionally, emotional mood can significantly impact memory retention. Research has demonstrated that a positive mood enhances recall and overall memory performance (Osaka et al., 2013). An increasing amount of research highlights the benefits of positive emotions for both mental and physical health (Catalino et al., 2014). Positive emotions broaden perceptual and cognitive horizons compared to negative emotions, encouraging individuals to focus on the bigger picture, while negative emotions often lead to focusing on details, which can result in forgetting (Madan et al., 2018). Sedikides and Skowronski (2020) describe the preference for positive content over negative as the triumph of good over evil, where the inclination towards positivity prevails. This perspective is particularly relevant in today's world, which is often inundated with negative news. Individuals may strive to seek out and retain as many positive stimuli as possible to help preserve their mental health and to prevent the onset and progression of depressive and anxiety disorders. A preference for positive stimuli may be associated with an inclination toward positive emotionality and enhanced psychological and social resources. By focusing on and remembering positive experiences, individuals can attract positivity into their lives, leading to greater happiness. In a simplified view, positive emotions play a crucial role in achieving social goals. Paakkanen et al. (2021) state that experiencing joy, contentment, and other positive emotions contributes to the development of lasting psychological, social, and intellectual capital, including increased resilience and psychological well-being. From a social perspective, emotional stimuli can be utilized to elicit positive emotions, thereby modifying mood and enhancing the experience of positive affect. This approach may enable individuals to recover more effectively from adversity and foster a more optimistic mindset. Ultimately, positivity can lead to greater inner balance, reduced stress, and improved well-being, all of which contribute to enhanced focus. When one's thoughts remain anchored, attention is retained, and memory is improved. Cultural differences also play a role in how individuals perceive and remember positive emotional stimuli, as emotional regulation and expression can affect memory retention. In some cultures, there's a strong emphasis on positivity, while others may adopt a more reserved or balanced approach to emotional expression. Research has indicated that individuals from societies, like those in East Asia, might not focus as much

on positive emotions as those from Western cultures, where personal happiness and positive experiences are often prioritized (Oishi et al., 2007). Similar results were found in Poland, which may be considered a culturally similar country to Slovakia, indicating that positive stimuli were better recalled than negative ones (Paulewicz et al., 2015). These cultural differences can affect not only how individuals process emotional stimuli but also how they encode and recall memories associated with positive emotions, hence our results should be interpreted with caution.

The final sub-goal was to identify the differences in the frequency of false associations when re-recognizing emotionally charged versus neutral visual stimuli. The results of the research study did not support the hypothesis that there would be a higher incidence of false associations when re-recognizing emotionally charged visual stimuli compared to neutral ones (Bessette-Symons, 2017; Dehon et al., 2010; Kensinger, 2009), nor did they indicate a significant difference between positively and negatively charged emotional stimuli. Non-significant results may be because false associations can arise from a variety of factors, including the way information is processed and acquired, individual differences in memory abilities, and cognitive biases. While emotional stimuli may be more memorable and attention-grabbing, this does not necessarily mean that they are more prone to false associations or memory distortions. One possible explanation for the similar rates of false associations is that emotional stimuli are both more engaging and more salient, making them easier to distinguish from similar but unrelated stimuli. This phenomenon may reflect the emotional enhancement of memory, where emotional content improves recognition ability. Furthermore, emotional content is often remembered and subsequently recalled more effectively than non-emotional content. Consequently, emotional stimuli may be beneficial in the workplace or educational settings. Emotional content could not only enhance memory retention but also help prevent students from confusing different materials and topics, thereby leading to improved memory and ultimately, better learning outcomes. Additionally, textbooks and study materials could be enriched with emotional content following further investigation and validation of these findings, as emotions appear to enhance memory without negatively impacting discriminative ability. However, it is necessary to consider that another possible reason for these results may be that the participants are students who regularly engage in memory training for their studies or work. Cognitive training promotes memory reliability. Moreover, psychologists may be hypothetically more resistant to the influence of emotionality on their cognitions. Nevertheless, since the participants were psychology students only rather than working professionals, this factor may be less relevant.

This knowledge is also crucial for investigating culture. Throughout an individual's life, culture shapes their values, goals, and behaviors, which can influence various cognitive processes, including memory and attention (Leger and Gutchess, 2021). Memory functions are also culturally conditioned and affected by cognitive processes. Additionally, there are differences in social norms and in the stimuli that elicit different responses. In some cultures, expressions of anger, violence, and poor treatment of animals may be perceived as more acceptable and viewed more positively than in others, such as in Europe. Similarly, individuals may be influenced by their family background to prioritize a certain emotional response. As our world becomes increasingly interconnected, it is essential to understand the systematic differences in cognitive functions across cultures. Within Europe, particularly in Slovakia, there has been insufficient attention to this issue. The influence of emotional content on memory and false recognition has not been studied yet, resulting in a lack of knowledge about this phenomenon in the country. Exploring this phenomenon is vital for societal advancement, enabling even smaller countries to elevate their standards and contribute scientifically to the understanding of phenomena across different cultures and countries.

The findings of the study are also important from an artistic perspective. For visual artists and photographers, this underscores the importance of creating works that evoke strong emotional responses. Art that captures or evokes emotions (whether positive or negative) is more likely to stay in the viewer's memory and have a lasting impact. The contrast between positive and negative emotional content can be an effective artistic strategy, used to evoke diverse responses, explore the complexity of human emotions, or convey specific narratives. Artists' focus on creating artwork with uplifting, hopeful, or joyful themes can be especially important in contemporary art and photography, where positive emotions are often used to counterbalance social stress or negativity.

The main limitation of this study is the heterogeneity of the research sample, which consists of a high number of young adults compared to a limited representation of individuals in middle adulthood. However, given that research on this phenomenon is still in its early stages in the country, this sample size may be considered sufficient and appropriate. In addition, unassessed long-term mental states of the

participants, especially from a long-term perspective, may pose a threat to internal validity. Nevertheless, it can be concluded that individuals worldwide exhibit different mental states, which is a natural aspect of humanity; thus, this threat is unlikely to significantly impact the results of the study. Furthermore, the participant's attitudes or motivations toward the experiment, as well as their memory performance, could present challenges. The intellectual capacity of the individuals involved could not be assessed in advance, primarily due to time constraints. However, given the selection criteria for the research sample, it is expected that the students' intellectual abilities fall within the normative range. Participants were also motivated by their genuine interest in contributing to scientific knowledge through their involvement in the study.

This research study contributes to our understanding of how the emotional charge of various stimuli can affect a person's cognitive abilities and memory performance. Since memory plays a key role in various everyday settings, such as the workplace and educational settings, individuals can improve their learning and memory retention by associating positive emotional values with the material they perceive. In practice, fostering a positive environment in schools or workplaces is beneficial. Such an environment can be created by the use of pleasant or cheerful images. In educational settings, positive emotions can be integrated into the content presented to students. The key is to link stimuli to enjoyable experiences that evoke pleasure and satisfaction, thereby enhancing students' ability to remember what they have learned. Additionally, memorization can be improved by listening to uplifting music or by experiencing a favorite scent that elicits positive feelings in individuals.

The study could serve as a foundation for further research in the field of investigating emotions and memory, which remains a significant challenge. Given that culture influences how emotions are perceived and experienced, as well as the information people remember, it is important to examine cross-cultural differences in order to understand the effects of emotions on memory retention across various cultural contexts. Research reflecting on these effects in clinical practice, education, or professional settings could further enhance our understanding of the role of emotional content in memory. Finally, this study could inspire the development and standardization of a database of visual stimuli characteristic of the Slovak environment, including the emotional valence of individual objects.

Conclusions

The purpose of this study was to explore the association between emotional experience and cognitive performance. Numerous factors influence memory performance and the formation of false associations, with emotion being one of the most significant. Our findings confirmed that emotionally charged stimuli are remembered more effectively than neutral visual stimuli. Specifically, individuals recalled positively charged stimuli more accurately and consistently. Several explanations may account for these findings, ranging from the basic brain function to the achievement of psychological homeostasis and the innate human tendency to maintain a positive outlook on life. Particular emphasis is placed on the social context as a key factor in interpreting the results of this study. The current era, characterized by heightened stress and an overload of negative information, fosters a greater inclination to pursue positive emotionality, inner peace, and overall well-being. This pursuit enhances an individual's ability to concentrate, maintain attention and, importantly, improve memory retention. This study contributes to a deeper understanding of how the emotional charge of different stimuli can affect cognitive abilities and memory performance. Considering the significant role of memory in a variety of everyday settings, such as the workplace and education, this research also offers practical applications. However, it is important to note that exposure to positive content can lead to improvements in life circumstances. Such changes can, in turn, result in reduced stress, enhanced well-being, improved focus, and better overall memorization. The results suggest that memory and learning outcomes can be improved by integrating positively charged emotional value into the information being processed. Furthermore, this study may serve as a foundation for future scientific research and provide a valuable basis for investigating cross-cultural differences in the impact of emotional content on memory.

Acknowledgements

The study was conducted in compliance with the ethical standards set by the Declaration of Helsinki (1964), and informed consent was provided to all participants.

The authors did not preregister their analysis plan.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, D.J. and Z.R.; methodology, D.J.; software, D.J.; formal analysis, D.J. and Z.R.; writing—original draft preparation, D.J.; writing—review and editing, D.J., Z.R. and P.S. All authors have read and agreed to the published version of the manuscript.

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